NISTIR 5855

Specification for Interoperability Between Ballistic Imaging Systems:

Part 1 - Cartridge Cases

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1.0 INTRODUCTION

Ballistic imaging systems provide firearms examiners or other trained operators with computer-based analysis tools to review and possibly link evidence to a crime. These systems use the powerful searching capabilities of the computer to match representations of images of recovered-bullet or cartridge-case crime-scene evidence against representations stored in a computer database. An analyst can create digitized images of the evidence that are used along with General Characteristic Descriptors (GCD) to create electronic "signatures" of the evidence. These signatures are then compared to the database entries and a ranking based on probability of match is returned and/or candidate images are returned for examination. In all cases the final match is confirmed by a trained firearms examiner with access to the original evidence.

Up to 200 Federal, State, and local forensic laboratories could make use of such imaging systems to perform ballistics imaging for law enforcement purposes. As of December 14, 1995, a significant number of laboratories already had or were scheduled to receive one of only two systems currently available: Drugfire™, developed by the Federal Bureau of Investigation (FBI) through a contract with Mnemonic Systems, Inc. (MSI); or IBIS™, produced by Forensic Technology, Inc., (FTI) and used by the Bureau of Alcohol, Tobacco, and Firearms (ATF). It is acknowledged in a Memorandum of Understanding[1] (hereinafter referred to as the MOU) that it is imperative that Drugfire and IBIS are interoperable. "Interoperability," as defined by the MOU, exists if the systems are able to (1) capture an image according to a standard protocol and in conformity with a minimum quality standard, and (2) exchange images electronically in such a manner that an image captured on one system can be analyzed and correlated on the other.

To facilitate the development of interoperable systems, a series of meetings was held at the National Institute of Standards and Technology (NIST) on January 22 and January 24, 1996, with representatives from the Office of Management and Budget (OMB), the FBI, ATF, NIST, and the system vendors MSI and FTI attending. As a result of discussions at these meetings, the group agreed that a NIST Interagency Report (NISTIR) should be created to define a minimal specification for interoperability.

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[1]MEMORANDUM OF UNDERSTANDING between the Office of National Drug Control Policy (ONDCP), Executive Office of the President, the Federal Bureau of Investigation (FBI), Department of Justice, and the Bureau of Alcohol, Tobacco, and Firearms (ATF), Department of Treasury, dated January 11, 1996.

The meeting participants also agreed that although the Drugfire and IBIS systems successfully accomplish the same objective, they use two fundamentally different methods to capture images: The Drugfire system acquires images created with oblique lighting (i.e., off-axis illumination); and the IBIS system acquires images created with annular lighting (i.e., axially symmetric illumination). These two types of images are dissimilar in appearance and content. Consensus was also reached on the statement that it has not been proven possible at this time to electronically translate the native images generated by either system to an image compatible with the other system, in part because of the differences in lighting technique (oblique vs. annular). Rather simple arguments were expounded to show that features visible with one type of illumination (e.g., oblique lighting) could be invisible with the other type of illumination (e.g., annular lighting)—and vice versa—when using charge-coupled-device (CCD) imaging systems with limited dynamic range. The possibility of future research leading to a method for electronic translation exists; however, the time estimated for successful completion of such research exceeds by at least an order of magnitude the time allocated for the development of an interoperability solution under the MOU.

Finally, to require that either system vendor revise its method used to acquire image data to be compatible with the other system would also require major revision of the software and proprietary algorithms used to generate the electronic signatures and search matches. This was not deemed feasible by any of the meeting participants.

Based on the above assumptions and conclusions, it was decided to produce a specification that would require the following: Each system shall have the capability to acquire images that can be transmitted to and correlated on the dissimilar system. This may require hardware and software modifications to either or both systems. It was deemed the responsibility of the relevant government agencies and system vendors (FBI, ATF, MSI, and FTI) to provide NIST with current, accurate, and complete information to permit the successful specification of such capabilities.

1.0.1 DEFINITIONS

The following basic definitions are presented for the purposes of encouraging clear and unambiguous understanding of the concepts presented in this document:

Image: An image is a bit-mapped grayscale representation of forensic evidence, encoded in either a lossless or lossy Joint Photographic Experts Group (JPEG) format.

Query: A query is a request to match provided forensic image and auxiliary information against a database of forensic information. The query must include all the information required by the target system and specify what information is requested in return. The query will be in the format of a Ballistics Data File (described below).

Ballistics Data File (BDF): A BDF is a collection of one or more electronic files designed to permit the transfer of forensic information between ballistic imaging systems. The BDF may contain, but is not limited to, one or more images with auxiliary data which may include general rifling characteristics, laboratory identification, specimen identification, operator identification, date of incident, date of image generation, image characteristics (size, magnification, etc.), and query information. The format of the BDF is specified in Section 3.0.

1.1 PURPOSE

This document is the first in a series of planned documents that will specify the hardware and software requirements to permit interoperability between the Drugfire and IBIS systems as specified by the MOU. The purpose of this first document is to define a specification that will permit cartridge-case image capture and electronic exchange of cartridge-case image information between the Drugfire and IBIS ballistic imaging systems. Requirements for imaging and correlation of bullets will be addressed in a future publication.

Interoperability, as defined by the MOU, is the capability of acquiring/creating ballistic images and auxiliary data (a Ballistics Data File) on either system and electronically transmitting that data to the dissimilar system in such a manner that the image and auxiliary data can be analyzed and correlated on the dissimilar system. It is recognized that from the standpoint of the user, expansion of this minimal definition may be desired to provide efficient operation; in particular, improvements in rapid, automatic, and unattended image transfer and correlation would greatly benefit system users. Extension of the minimal interoperability definition is considered by the MOU in Section IV, subsection C, "Future Standards," which requests NIST, in coordination with the American National Standards Institute, to sponsor the development of future standards for the capture and transfer of scanned firearm ballistics information. Later publications can be produced to address these issues.

With regard to image acquisition, the concept of interoperability is not a yes/no situation but rather a matter of degree of interoperability. It must be recognized that acquiring images on a non-native system may produce subtle differences in image "quality" that could result in changes in the match probability. To investigate adequately the effect of all expected differences against all reasonable image databases would require a complex long-term research project that is beyond the scope of this project. However, small variations in match probability are already tolerated, since even within a system type there can be small system hardware variations or operator differences. Thus interoperability must not be defined as requiring "identical" images from the dissimilar system but images that will produce "good" correlations or matches on the dissimilar system. At present we do not have enough information to quantify "good," but we expect that the basic specifications detailed below will support a reasonable definition of interoperability for cartridge cases. Remaining quality issues can be investigated during field tests of the modified systems, and likely be resolved with minor adjustments.

The proposed scenario for a data transaction consists of the following:

1. Image generation hardware used to capture one or more cartridge-case images compatible with the host target system is provided with the remote laboratory query system.

2. Sufficient auxiliary information to specify the evidence fully and document the query is manually entered into the system and incorporated into a Ballistics Data File (BDF). The query may reasonably request the return of only that information that the target system may be capable of returning. The format and content requirements of the BDF are specified in Section 3.0.

3. The BDF is transmitted electronically from the remote laboratory query system to the host target system through standard voice-grade telephone lines and commercially available modems. System transmission capabilities are specified in Section 4.0.

4. The host target system returns the requested information (if possible) consistent with the specifications using the BDF format as described in Section 3.0.

5. The process (1 through 4) may be repeated, in full or in part, until the desired information is obtained.

1.2 SCOPE

For successful system interoperability, two requirements must be met: (1) each system must have sufficient capability to produce the required data, and (2) proper operating procedures must be established to produce data of sufficient quality. This specification will focus only on the former and will establish a minimum range or boundary conditions on the hardware capability with an emphasis on being as open as possible. An example specification could state: "An oblique light source adjustable from an angle of 55° to 65° with respect to the specimen is required and the specimen cartridge case is required to be capable of being tilted from 0° to 10° from normal." The exact angles needed to produce a quality image will depend on the nature of the specimen and is an operational consideration. Although operator experience is understood to be crucial to both systems, it is the responsibility of the system vendors and sponsors to provide quality training and/or user manuals to specify the operating procedures necessary to achieve interoperability.

This document is designed to provide a complete specification of hardware requirements for the capture of cartridge images (and ancillary data) for each system. In addition to hardware requirements, there may be software functions that must be implemented by one or both systems to generate or accept the non-native cartridge-case images and also perform proprietary processing before a correlation can be performed. This document does not directly address how the software functions will be implemented; rather, it specifies the format and content of the data to be exchanged. It is the responsibility of the system vendors to implement the appropriate software functions as required by their system. Cooperation between the vendors is expected to provide assistance in developing non-

proprietary operational procedures for identifying the required cartridge-case characteristics as specified in the BDF described in Section 3.0.

This document does not restrain future system upgrades. However, as much as practical, the system vendors are encouraged to provide backward compatibility to the specified BDF format that will permit data acquired on legacy hardware to be searched successfully on newly created databases. It is understood that the elements of forensic databases may be of relatively temporary value, and the entire database could in time be supplanted by a significantly improved database structure. Thus, future improvements to the systems are not restricted with any requirement that newly created databases be completely compatible or searchable with data generated according to this specification.

2.0 IMAGE ACQUISITION—FUNCTIONAL REQUIREMENTS

A schematic of a simplified optical configuration for ballistic imagery is shown in Figure 1. Two types of light sources are indicated here: oblique lighting and axially symmetric (annular or ring) lighting. The cartridge is the object in the object plane. The objective lens (and any other lenses in the system, such as a relay lens between the objective lens and the camera) images the object (the cartridge case) in the object plane onto the image plane on the surface of the detector in the camera. There is a preferred optical axis that is usually defined by the objective lens and center of the camera. The requirements listed here refer to system capabilities and are to be distinguished from any procedural requirements or requirements that may be referred to as an "art" or practice; that is, these specifications relate to the capabilities of the data-collection system and do not attempt to define the requisite competence of the operator. The resulting digitized image will have an approximately square pixel, the aspect ratio (width/height) of which will be included in the Ballistics Data File (BDF).

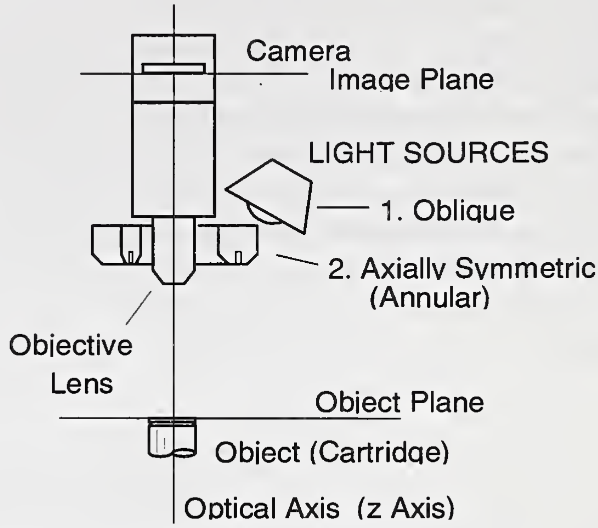

Figure 1. *Optical configuration for ballistics cartridge imagery used in this document. (Axially symmetric light source shown in partial cross-section.)*

There are several types of images that can be associated with ballistics data. We specify here requirements for those images using pristine samples. There are three main properties of the system that spatially specify the optical configuration to permit proper imagery: (1) The magnification of the microscope objective used or, alternatively, the resolution of the optical system required (since microscope objectives are fairly standard it is often easier to specify the magnification than the optical resolution of the objective); (2) the object pixel coverage, expressed in pixels/mm, that gives the number of linear pixels per unit distance in the object plane to provide a good image; and (3) the number of pixels required to make a useful image, which will be referred to as the required pixels along an axis or the horizontal-by-vertical pixel count of a two-dimensional area.

It is tempting to specify the camera grayscale response and capabilities, the camera uniformity, the camera and overall system linearity, and the illumination uniformity. However, it is difficult to write such specifications since they are not generally known by the manufacturers of the ballistic imagery equipment and did not enter into their considerations in the development of the apparatus. The apparatus works, and the component parts are, for the most part, standard off-the-shelf items. Further, such specifications are not readily available from the manufacturers of the cameras or the light sources. One alternative is to provide unambiguous measurement procedures to establish these parameters based on standardized targets. The other alternative is to ignore them entirely, essentially assuming that the commonality of the components used, combined with the training of the operators, will assure

sufficient image interoperability as far as these parameters are concerned. To measure these parameters is not a simple task since a number of systems would have to be measured under a variety of ambient conditions and the results averaged. If it should be determined that these parameters (the camera and illumination characteristics) are essential to interoperability, then this document will be appropriately revised.

There are more critical features of the image acquisition process that do need to be specified, and these essential features are addressed in this document. The type of lighting used and the overall magnification of the system can be critical to obtaining images necessary to provide interoperability. The specifications for the axially symmetric lighting are covered in Section 2.1 and for the oblique lighting in Section 2.2.

2.1 IBIS™ SYSTEM: AXIALLY SYMMETRIC (ANNULAR) LIGHTING

Figure 2 shows a fiber-optic ring light as the only source of illumination. Table 1 lists the permissible values and ranges of optical configurations that will permit proper imaging of cartridge cases using an axially symmetric illumination system. Standard microscope objectives are suggested although a zoom microscope objective can also be used. The height of the ring light is approximately 70 mm ± 10 mm and the diameter is 55 mm ± 10 mm.

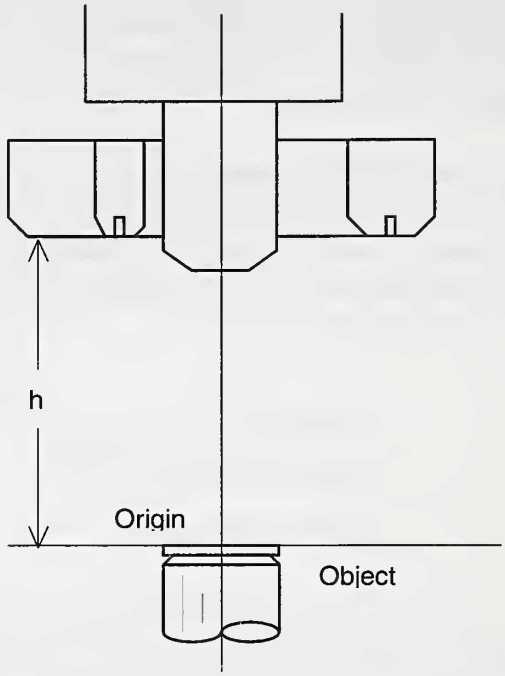

Figure 2. *Axially symmetric lighting showing a fiber-optic ring light.*

Table 1. Cartridge Image Requirements for Axially symmetric Illumination

Cartridge Case Object	Microscope Objective Magnification	Object Pixel Coverage (pixels/mm)	Required Pixels (Horizontal x Vertical)
Breech Face	1	104 ± 1 %	480 x 480
Firing Pin Impression	1.5	155 ± 1 %	480 x 480
Extractor Marks			
Ejector Marks	1.5	155 ± 1 %	480 x 480
Chamber Walls			
Rimfire	2	209 ± 1 %	480 x 480

2.2 DRUGFIRE™ SYSTEM: OBLIQUE LIGHTING

Figure 3 shows the configuration for oblique lighting denoted by "O" subscripts. In the case of imaging with oblique light there may be a preferred direction with which the object must be oriented. Call that direction the x-axis. For example, linear scratches might be aligned with the x-axis in order to best exploit the oblique lighting. The oblique light should be oriented with its center above the y-axis requiring ϕ_O to be approximately 90°. The angle that locates the center of the cross-section of the lamp is θ_O, and the lamp subtends an angle $\Delta\theta_O$ centered about θ_O. The extent of rotational coverage of the lamp will be denoted by $\Delta\phi_O$. The lamp should be shaded so that the lamp illumination surface is not directly observable by the operator under normal data-taking conditions. There are no requirements for the reflectivity of the shade. The light from the lamp or its shade must not be permitted to directly illuminate the objective lens. The tilt of the cartridge surface toward the lamp is specified by $\Delta\theta$.

Table 2 and Table 3 list the permissible values and ranges of optical configurations that will permit proper imaging of cartridge cases for the oblique lighting system. These are intended to provide the same kind of flexibility in "high and tight" lighting as would be employed by a firearms examiner.

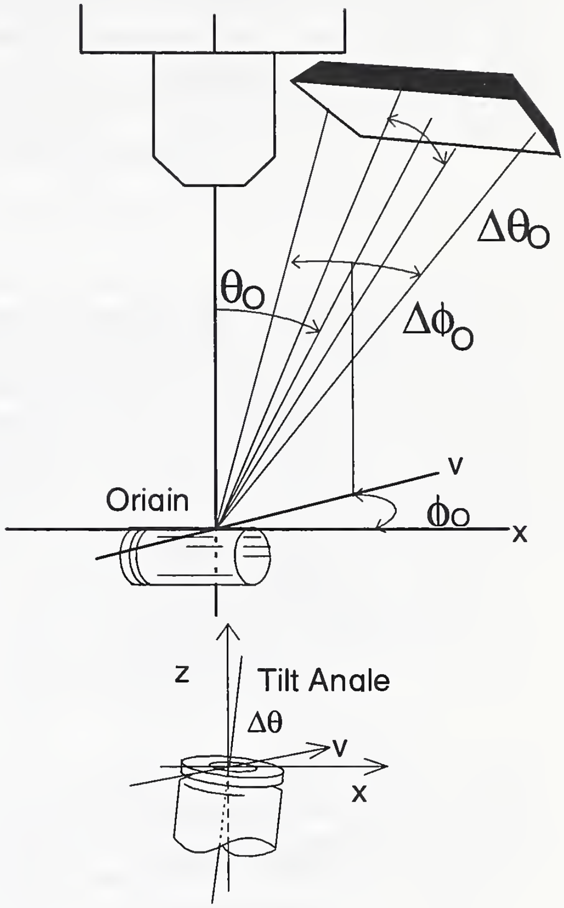

Figure 3. *Oblique lighting and target-alignment specification variables.*

Table 2. Cartridge Lighting Configuration Requirements	
Quantity	Value or Range
θ_O	5° to 45°
$\Delta\theta_O$	20° ± 10°
$\Delta\phi_O$	45° ± 10°
$\Delta\theta$	0° to 10°

Table 3. Cartridge Image Requirements for Oblique Illumination			
Cartridge Case Object	Microscope Objective Magnification	Minimum Object Pixel Coverage (in pixels/mm)	Minimum Required Pixels Along Axis of Cartridge
Breech Face: High Magnification	3	150	Not Applicable
Breech Face: Medium Magnification	2	100	Not Applicable
Breech Face: Low Magnification	1.5	75	Not Applicable
Firing Pin Impression	1.5	150	Not Applicable
Extractor Marks	1.5	150	Not Applicable
Ejector Marks	1.5	150	Not Applicable
Chamber Walls	1.5	150	450
Rimfire	1.5	150	Not Applicable

3.0 DATA FORMAT SPECIFICATION

This section shall define the content, format, and units of measurement for the interchange of cartridge information between similar or dissimilar systems. Such information may be used for searching and determining correlations with other cartridge images stored in the master files. This data shall consist of a variety of mandatory and optional items including transaction information, general characteristic descriptors, various parameters, and compressed digitized images. This information is intended for interchange between law enforcement agencies for identification purposes.

3.1 DATA FORMAT SELECTION

Choosing a data format specification that will efficiently and properly effect the interchange of data between automated ballistic recognition systems requires that several conditions be met: (1) Since image quality is of foremost importance, the exchange of image data must be totally lossless to enable accurate database correlation. However, lossy image data may be tolerated for image storage and visual image comparison purposes. (2) The specification must be capable of handling and processing information expressed as eight-bit grayscale image pixel values. (3) There must be provisions for including descriptive textual information with each image. This information shall be recorded using the seven-bit American National Standard Code for Information Interchange (ASCII) as described in ANSI X3.4 or ISO 646-1983, *7-bit Coded Character Set for Information Interchange*.[2] (4) In addition to dissimilar ballistic imaging hardware, the specification must be operational across multiple computer platforms. (5) There must be a capability for future expansion.

Several common file formats were considered that could be used for the exchange of ballistic images and textual information during the process of searching for a data format specification. The features and capabilities of each were evaluated in light of the requirements specified for handling transactions and performing correlations. The selection process was also based on the desire to choose a format that was recognized as a standard. None of those examined was found to exactly meet all of the criteria.

Since no existing standard meets all of the stated requirements, a format is defined in this report that is based on an existing and recognized forensic information interchange standard, namely, *Data Format for the Interchange of Fingerprint Information* (ANSI/NIST-CSL 1-1993). This standard serves as the model for the data interchange format for ballistic information. It was originally developed for the interchange of fingerprint information, but it is currently being expanded to include other types of forensic identification information. Federal, state, and local law enforcement administrations are employing this method as a means of interchanging forensic data. Use of this framework can now provide the capability of incorporating ballistics information into a format that may be adopted for the interchange of many types of forensic data relating to a specific incident. The standard has provisions for the inclusion of transaction information, system information, general characteristic descriptors, and images. As no specific compression algorithm is mandated by the standard, both uncompressed and compressed eight-bit grayscale data can be encoded and exchanged for this application. The standard

[2]Available from the American National Standards Institute, 11 West 42nd Street, New York, NY10036

can also be expanded for the handling of request and response data. Being platform independent and simple in structure, the chosen format has the capabilities to handle transaction requests, textual descriptive data, and compressed or uncompressed images. This approach is well suited for the exchange and processing of BDFs.

3.2 DATA CONVENTIONS

Scanned grayscale images shall consist of pixels, each of which shall be quantized to eight bits (256 gray levels) and shall be contained in a single byte. Each grayscale value shall be expressed as an unsigned byte. A value of zero shall be used to define a black pixel and a value of 255 shall be used to define a white pixel.

A pair of reference axes shall be used to describe the position of each pixel within an image. The origin of the axes, pixel location (0,0), shall be located at the upper left-hand corner of each image. The x-coordinate (horizontal) position shall increase positively from the origin to the right side of the image. The y-coordinate (vertical) position shall increase positively from the origin to the bottom of the image. For every grayscale image scanned and formatted, the scan sequence of the exchanged image shall be assumed to have been left to right and top to bottom.

The order for transmission of both the ASCII text and the binary representations of bytes shall be most significant byte first and least significant byte last. Within a byte, the order of transmission shall be most significant bit first and least significant bit last. Figure 4 illustrates the order of transmission of the bytes and bits within a file.

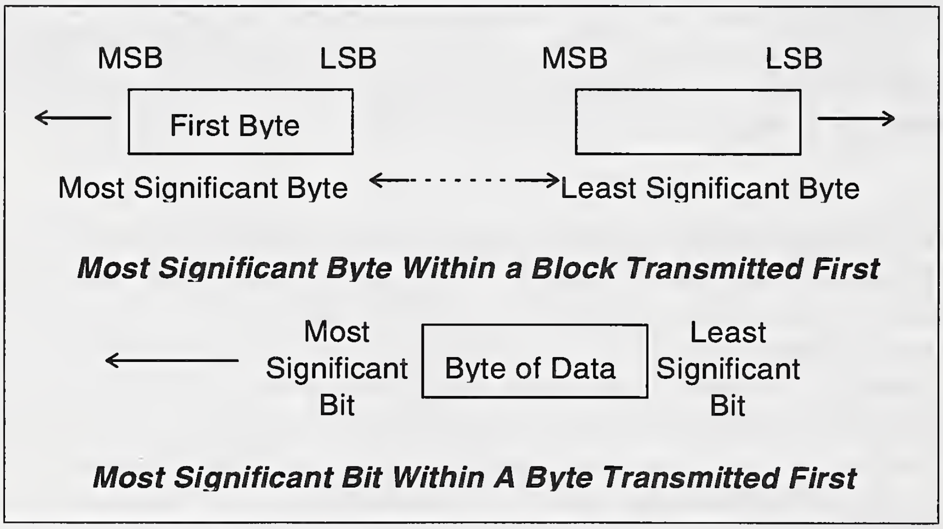

Figure 4. *Byte & Bit Ordering*

3.3 IMAGE DATA

3.3.1 LOSSLESS JPEG COMPRESSION

Processing requirements for the exchange of image files is costly both in terms of image transmission time and storage usage. For this reason, it is desirable to decrease the time required to transmit the data and the amount of storage needed to contain the images. This interchange format provides for the exchange of uncompressed or compressed images. By employing the lossless mode of the JPEG[3] algorithm, a compression ratio of approximately 2:1 can be achieved without any loss to data or image quality. Further, the JPEG algorithm also can be used in the lossy baseline mode for even greater compression for image storage and subsequent visual comparisons of images.

3.3.2 JPEG FILE STRUCTURES

Image data to be compressed shall be compressed in accordance with the JPEG algorithm. Data resulting from this compression technique may be considered as a stream of marker segments or data blocks. Every JPEG interchange file begins with a Start Of Image (SOI) marker code segment (consisting of a unique two-byte marker code), followed by the JPEG encoded image with associated tables for decoding, and ends with an End Of Image (EOI) marker segment (consisting of a unique two-byte marker code).

During development of the JPEG interchange format, the need was recognized to include application-specific information in the JPEG interchange file. This need was fulfilled by the JPEG designers who provided application marker segments (APP_n) for the interchange of such information.

A common application marker segment (APP0) has been recognized as a wrapper for JPEG encoded images. The JPEG File Interchange Format (JFIF) Version 1.02 will be used for the exchange of compressed image data. Information that is missing from the JPEG stream that may be required to process the image is provided by this marker segment. It also allows other applications to import JPEG encoded files. The JFIF is a minimal file format that enables JPEG bitstreams to be exchanged among a wide variety of platforms.

The JFIF marker segment is entirely compatible with the standard JPEG interchange format. The only requirement is the inclusion of the JFIF APP0 marker segment, which is imbedded in the compressed JPEG interchange file immediately following the SOI marker.

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[3] ISO International Standard 10918-1, Information Technology - Digital Compression and coding of Continuous-Tone Still images Part 1: Requirements and Guidelines (Commonly referred to as JPEG). Available from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

3.4 FILE DESCRIPTION

This section defines the composition of a BDF to be exchanged between laboratory systems. Each BDF shall contain one or more logical records. Two logical records are defined for the purpose of exchanging ballistics information. One is the transaction record that shall contain information pertaining to the transaction itself. The other logical record contains descriptive textual information, the image data, or both. Descriptive and image data may be from a specimen submitted for correlation or the results of a correlation.

3.4.1 TRANSACTION RECORD

The transaction shall be defined by a Type-1 record. Its presence is mandatory and shall be used with each transaction. There shall be one—and only one—transaction record in a BDF. It shall always be the first record exchanged and consists entirely of ASCII textual data. The Type-1 record shall provide information describing type and use of transaction. It shall also include a listing of each record present in the BDF and other information items.

A series of tagged fields shall be used to provide information required to process the transaction. The data fields in this record shall be recorded in variable-length ASCII fields. The fields contained within the record shall be numerically ordered and their contents shall be as specified by this report.

3.4.2 IMAGE RECORD

The image record shall be defined as a Type-12 record.[4] Depending on the purpose of the transaction, there may be from zero to any number of these image records. This record type shall be used to exchange a combination of ASCII and binary image data within a single logical record structure. The Type-12 record shall provide general characteristic descriptors and up to one scanned image. At the beginning of the record, a series of tagged fields shall provide the descriptor information associated with the binary image data optionally present in the last field of the logical record.

The data fields in this record shall be recorded in variable-length fields using ASCII code. The fields contained within the record shall be numerically ordered and their contents shall be as specified in this report.

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[4]The record type numbers and field numbers within each record type may not always be sequential. Gaps in the numbering system are a result of harmonizing this report with the fingerprint interchange standard.

3.4.3 IMAGE DESIGNATION CHARACTER (IDC)

This construct shall be used to identify and link together multiple scannings of the same view of a specimen. For example, if it is desired to use different illumination levels to scan and include two or more renditions of the same cartridge case in a single BDF, this construct allows the receiving system to recognize and link the multiple scannings. The IDC properly identifies logical records that pertain to the same image.

Each Type-12 record in a BDF shall include an IDC. This IDC shall be used to relate information items in the file contents field of the Type-1 record to each Type-12 record. For a BDF containing general characteristic or image data, the value of the IDC shall be a sequentially assigned positive integer starting from one and incremented by one. For transactions that are limited to returning or requesting a list of specimen identification numbers, the IDC shall be zero.

3.5 RECORD FORMAT

For both types of logical records, several information fields shall be present. Data entries within information fields may be further subdivided into information items that are used to convey different aspects of the data contained in that field. In addition, certain fields may contain subfields consisting of multiple entries of the same type of information.

3.5.1 INFORMATION SEPARATORS

Although flexible, this format requires a means of identifying the beginning and end of each information field and each piece of information within each field.

Mechanisms for delimiting information fields within a logical record, items within a field, and multiple occurrences of information within the same field shall be implemented by use of four ASCII information separators. These characters, defined in ANSI X3.4, shall be used to separate and qualify information in a logical sense: the File Separator (FS) character shall be used to mark the end of a logical record; the Group Separator (GS) character shall be used to delimit fields; the Unit Separator (US) character shall be used to delimit information items within a subfield; and the Record Separator (RS) character shall delimit multiple occurrences of the same subfield. Table 4 lists these ASCII separators, their hex code equivalents, and a description of their use within this document. These separators shall be in addition to any other symbols, punctuation, or delimiters as specified in this standard.

Table 4. Information Separators		
ASCII CHARACTER	HEX CODE	DESCRIPTION
FS	"1C"	Terminates BDF logical record
GS	"1D"	Delimits fields within the BDF logical record
RS	"1E"	Delimits multiple data entries (subfields) of an information field
US	"1F"	Delimits individual information items of the field or subfield

These four characters shall be used only as separators of data items, and only one of them may be used between any two data items. A US character cannot immediately precede an RS character; an RS cannot immediately precede a GS; and a GS cannot immediately precede and FS character. The FS character separator will take precedence over the GS; the GS over the RS; and the RS over the US. Annex A illustrates the use of these separator characters.

All information fields used in the BDF logical records shall be numbered in accordance with the numbering scheme described in this report. The format of each field shall consist of a field identifier number followed by a colon (:), followed by the information item(s) appropriate to that field. Field identifier numbers within each logical record shall be in ascending order. Individual information items within the subfield shall be separated by the US character. Repeating subfields within a field shall be separated by the RS character. In addition to the field identifying number, information fields shall be separated from other information fields by the GS character. Annex A contains an example of the use of the format, which illustrates the layout for both logical record types.

3.5.2 RECORD LAYOUT

For each record type, information fields that are used shall be numbered in accordance with this report. The format for each field shall consist of a field identifier number followed by a colon (:), followed by the information item(s) appropriate to that field. The field numbers shall have the format "1.XX" for the Type-1 record, and "12.XXX" for the Type-12 record. The "XX" or "XXX" entry shall be the assigned field number within that record type.

3.6 TYPE-1 TRANSACTION RECORD

The purpose of this logical record is to convey information pertaining to the interchange transaction itself. Table 5 summarizes the fields appearing in this record. For each field, its identifier, condition code, number, and description are listed. Under the CONDITION heading, entries identify the mandatory or optional nature of the field. An entry of "D" signifies that the field is required for transactions targeted for a DRUGFIRE system. An entry of "I" signifies that the field is required for transactions targeted for an IBIS system. An entry of "O" implies the field is optional for both.

Table 5. Transaction Records Fields

IDEN-TIFIER	CONDITION	FIELD NUMBER	FIELD DESCRIPTION
LEN	D/I	1.01	Logical Record Length
VER	D/I	1.02	Version Number
CNT	D/I	1.03	File Content
TOT	D/I	1.04	Type of Transaction
DAT	D/I	1.05	Date of Transaction
PRY	O	1.06	Priority
DLI	D/I	1.07	Destination Laboratory
OLI	D/I	1.08	Originating Laboratory
TCN	D/I	1.09	Transaction Control Number (Submitted)
TRN	D/I	1.10	Transaction Response Number (Host)
NUM	D/I	1.11	Number of Matches or Images Requested

3.6.1 FIELD 1.01: LOGICAL RECORD LENGTH (LEN)

This mandatory ASCII field shall contain the total count of the number of bytes in this Type-1 logical record. The count shall include every character of every field contained in the record and the information separators. This field is terminated by the GS character.

NOTE: Although it may not always be explicitly repeated in the remainder of this document, use of separator characters within the BDF logical records will always be observed. Specific information items within a field or subfield shall be separated by the US character, multiple subfields shall be separated by the RS character, and fields shall be separated by the GS character.

3.6.2 FIELD 1.02: VERSION NUMBER (VER)

This mandatory four-byte ASCII field shall be used to specify the version number of the implementation creating the file. The most significant two bytes indicate the major revision and the least significant two bytes the minor revision. Version 1.00 is the current revision.

3.6.3 FIELD 1.03: FILE CONTENT (CNT)

This mandatory field shall list each of the logical records in the BDF by record type. It also specifies the order in which the remaining logical records shall appear in the BDF. Consisting of one or more subfields, each subfield shall contain two information items describing a single logical record found in the current BDF. The subfields shall be entered in the same order in which the logical records shall be transmitted. The RS separator character shall be entered between the subfields.

The first subfield shall relate to this Type-1 transaction record. The first information item within this subfield shall be a "1," indicating that this is a Type-1 record consisting of transaction information. The second information item of this subfield shall be the number of the Type-12 records following. This number is also equal to the count of the remaining subfields of Field 1.03. The US character separator shall be entered between the first and second information items.

The remaining subfields of Field 1.03 shall each be composed of two information items. The first information item shall be the number "12" indicating an image record. The second information item shall be the IDC associated with the logical record pertaining to that subfield. The IDC shall be a positive integer greater than or equal to zero. The US character shall be used to separate the two information items. The uncompressed or JPEG encoded images in the BDF must appear in the same order as stated in this field.

3.6.4 FIELD 1.04: TYPE OF TRANSACTION (TOT)

This mandatory field shall contain an identifier designating the type of transaction contained in the BDF. An entry chosen from Table 6 shall be inserted in this field to identify the subsequent action or processing to be performed. Multiple transaction codes shall require the use of multiple Type-12 records.

Table 6. Transaction Codes	
TRANSACTION CODE	TRANSACTION DESCRIPTION
CORGCD	Correlate Using General Characteristic Descriptors
CORIMG	Correlate Using Descriptor and Image Data
SNDRES	Send Response to Submitter
REQLIS	Request List of Image Numbers
SNDLIS	Send List of Numbers for Correlated Matches
REQIMG	Request One or More Images
SNDIMG	Send Requested Images

3.6.5 FIELD 1.05: DATE OF TRANSACTION (DAT)

This mandatory field shall contain the date that the transaction was initiated. The date shall appear as eight digits in the format CCYYMMDD. The CCYY characters shall represent the year of the transaction; the MM characters shall be the tens and units values of the month; and the DD characters shall be the tens and units values of the day in the month. For example, 19960315 represents March 15, 1996. The transaction date shall not be later than the current date.

3.6.6 FIELD 1.06: PRIORITY (PRY)

When this field is used, it shall contain a single information character to designate the urgency with which a response is desired. The values shall range from 1 through 4, with "1" denoting the highest priority. The default value shall be "4" if no value is indicated.

3.6.7 FIELD 1.07: DESTINATION LABORATORY IDENTIFIER (DLI)

This mandatory field shall contain the identifier of the laboratory designated to receive the transmission. The size and data content of this field shall be user-defined and in accordance with the receiving laboratory.

3.6.8 FIELD 1.08: ORIGINATING LABORATORY IDENTIFIER (OLI)

This mandatory field shall contain the identifier of the laboratory originating the transaction. The size and data content of this field shall be user-defined and in accordance with the laboratory submitting the transaction.

3.6.9 FIELD 1.09: TRANSACTION CONTROL NUMBER (TCN)

This mandatory field shall contain the Transaction Control Number as assigned by the originating laboratory. A unique control number shall be assigned to each transaction. This field is intended to track the transaction to be processed. The specimen identification is contained in the Type-12 record. For any transaction that requires a response, the respondent shall refer to this number when communicating with the originating laboratory.

3.6.10 FIELD 1.10: TRANSACTION RESPONSE NUMBER (TRN)

This is a mandatory field when used by a host system to respond to a transaction from a remote system. It shall contain the Transaction Response Number as assigned by the host system. Results of correlations are stored using this number as a pointer. This field is intended to track the results of a submitted transaction—not to identify a particular specimen or stored image.

3.6.11 FIELD 1.11: NUMBER OF MATCHES OR IMAGES (NUM)

This mandatory field serves two purposes. First, it can contain the number of matches resulting from a correlation. Second, it can contain a count of the number of images to be downloaded. This count would be used by a host system to download a specific number of images from a list formed as a result of a correlation.

3.7 TYPE-12 TRANSACTION RECORD

This record type is used to provide information for image requests submitted to a remote host system for correlation, or to request one or more specific images be downloaded from a remote host system. It is also used by the remote host system to return correlation results (an image or list of probable candidates) or to download one or more requested images. For correlation requests, this logical record contains the required general characteristic descriptor information in addition to the scanned image data from the cartridge. When used by the host system to return a probable candidate image or a requested image, the general characteristic descriptors and image data previously stored on the host system will be returned. Each Type-12 logical record shall contain pixel data from a single image or no pixel image data. Multiple images shall require multiple Type-12 logical records.

Table 7 summarizes the image record fields. For each field, the identifier, condition code, field number, and a brief description are listed. The following paragraphs describe the data contained in the fields for the Type-12 record. Each field shall begin with the number of the record type followed by a period, followed by the appropriate three-character field number, followed by a colon.

Table 7. Image Record Fields			
IDENTIFIER	CON-DITION	FIELD NUMBER	FIELD DESCRIPTION
LEN	D/I	12.001	Logical Record Length
IDC	D/I	12.002	Image Designation Character
TST	D/I	12.003	Test or Evidence
SSI	D/I	12.004	Submitted Specimen Identification Number
HSI	D/I	12.005	Host Specimen Identification Numbers
BIT	D/I	12.006	Ballistic Image Type
DTI	D/I	12.007	Date of Incident
OPI	D	12.008	Operator Identification
ICS	D/I	12.009	Image Capture System
ITS	D/I	12.010	Image Target System
CAL	D/I	12.011	Caliber Description
FAM	D	12.012	Caliber Family
ISP	D/I	12.013	Image size in Pixels
IPM	O	12.014	Image size in mm.
GCA	D/I	12.015	Grayscale Compression Algorithm Used
CLC	D/I	12.016	Camera Linearity Correction
COM	O	12.017	Comment
CARTRIDGE CASE:			
BMT	D	12.020	Breech Face Marking Type
XBP	I	12.021	External Breech Face Circle Position
IBP	I	12.022	Internal Breech Face Circle Position
FPI	D	12.023	Firing Pin Impression Shape
FPM	D	12.024	Firing Pin Impression Marks Descriptor

IDENTIFIER	CON-DITION	FIELD NUMBER	FIELD DESCRIPTION
FDD	D	12.025	Firing Pin Drag Descriptor
FPP	I	12.026	Firing Pin Position
EEL	D	12.027	Ejector/Extractor Locations
EMP	I	12.028	Ejector Mark Position
ECP	I	12.029	Ejector Contour Position
RCP	I	12.030	Rimfire Contour Position
IMAGE DATA:			
IMG	D/I	12.999	Image Data

3.7.1 FIELD 12.01: LOGICAL RECORD LENGTH (LEN)

This mandatory ASCII field shall contain the total count of the number of bytes in this Type-12 logical record. This count shall account for every byte of every field (including the image data) contained in the record and the information separators. The GS character shall separate the length of Field 1.01 from the next field.

3.7.2 FIELD 12.002: IMAGE DESIGNATOR CHARACTER (IDC)

This mandatory ASCII field shall be used to identify the image data contained in this record. The IDC contained in this field shall match the IDC found in the file content field of the Type-1 record. If the transaction is a returned or submitted list of specimen identification numbers, then the IDC shall be zero.

3.7.3 FIELD 12.003: TEST OR EVIDENCE (TST)

This mandatory ASCII field identifies the specimen as either test or evidentiary. This item shall contain either "TEST" or "EVID" to indicate the nature of the image. This field shall contain a maximum of one entry.

3.7.4 FIELD 12.004: SUBMITTED SPECIMEN IDENTIFICATION (SSI)

This mandatory field shall contain the identification number of the specimen that is recognized by the submitting laboratory. The content and format of this field shall be in accordance with the laboratory that is in possession of the specimen and is submitting the query.

3.7.5 FIELD 12.005: HOST SPECIMEN IDENTIFICATION NUMBERS (HSI)

This field shall contain a list of one or more specimen identification numbers belonging to and recognized by the host laboratory. This field may contain the image identification numbers of the images owned by the host laboratory obtained from a correlation search. It can also be used by a remote laboratory for submitting a request to download one or more images from the host laboratory. This field shall consist of one or more subfields, each subfield containing the identification of a unique specimen image that may include a case number. The content and format of this field shall be in accordance with the host laboratory.

3.7.6 FIELD 12.006: BALLISTIC IMAGE TYPE (BIT)

This mandatory ASCII field contains one information item. It is intended to identify the type of ballistic image or specimen description contained in this record. This item shall contain one entry selected from Table 8. This field shall contain a maximum of one entry.

Table 8. Image Types

IMAGE CODE	IMAGE TYPE
BRF	Breech Face
FRP	Firing Pin
EJM	Ejector Marks
EXM	Extractor Marks
RMF	Rimfire
CRT	Cartridge Case

3.7.7 FIELD 12.007: DATE OF INCIDENT (DTI)

This field shall contain the date that the incident occurred. The date shall appear as eight digits in the format CCYYMMDD. The CCYY shall represent the year of the transaction; the MM shall be the value of the month; and the DD the day of the month. For example, 19960229 represents February 29, 1996. The incident date shall not be later than the current date.

3.7.8 FIELD 12.008: OPERATOR IDENTIFICATION (OPI)

This ASCII field shall contain the identity of the operator that captured the image. Its content and format shall be determined by the formatting laboratory.

3.7.9 FIELD 12.009: IMAGE CAPTURE SYSTEM (ICS)

This field shall contain a description of the system that captured the image. It can consist of five information items separated by the US character. The first item is mandatory and shall contain "DRUG" or "IBIS" to indicate the manufacturer of the capture system. The remaining items are optional and can be put in any order: the model number; the version of the image capturing software, the computer platform to which the acquisition system is attached, and the operating system installed on the platform.

3.7.10 FIELD 12.010: IMAGE TARGET SYSTEM (ITS)

This field shall identify the target system for which the image was captured. It shall be assumed that the parameters and settings required by the target system were in effect at the time of image capture. This field shall consist of one or more information items. The first item shall contain "DRUG" or "IBIS" to indicate the manufacturer of the target system. An optional second information item may be present to convey the model number of the target system.

3.7.11 FIELD 12.011: CALIBER DESCRIPTION (CAL)

This mandatory field shall contain the specimen's caliber type. An entry from Table 9 shall be inserted in this field. Classifications not found in Table 9 shall be encoded as two information fields separated by the US character separator. The first information item will be the numeric caliber (approximate diameter). The caliber will normally be expressed in 100ths of an inch. If the caliber is stated in millimeters, the number of millimeters will immediately be followed by "mm." The second information item shall contain a common qualifier for the caliber size. For example, a 22 Winchester American would contain "22" as the first information item, and "Winchester American" or "WA" as the second information item. Multiple subfields separated by the RS character may be used for those instances when the caliber cannot be determined with certainty.

Table 9. Common Caliber Types	
CALIBER CODE	DESCRIPTION
22SH	.22 Short
22LR	.22 Long Rifle
22WM	.22 Winchester Magnum Rimfire
223R	.223 Remington (5.56 x 45 mm)
25AU	.25 Automatic (6.35 mm Auto)
30CA	.30 Carbine (7.62 x 33 mm)
3006	.30-06 Springfield (7.62 x 33 mm)
3030	.30-.30 Winchester (7.62 x 63 mm)
308W	.308 Winchester (7.62 x 51 mm NATO)
762R	7.62 x 39 mm (M43) Russian
32AU	.32 Auto (7.65 x 17 Auto)
32SW	.32 Smith & Wesson
32SL	.32 Smith & Wesson Long (CF)
357M	.357 Magnum
38AU	.38 Auto
38SW	.38 Smith & Wesson
38SP	.38 Special
380A	.380 Auto (9 mm Browning Short)
9LUG	9 mm Parabellum (LUGER)
10AU	10 mm Auto
40SW	.40 Smith & Wesson
44RM	.44 Remington Magnum
44SS	.44 Smith & Wesson
45AU	.45 Auto
UNKN	Unknown/Unable to Determine

3.7.12 FIELD 12.012: CALIBER FAMILY (FAM)

This optional field shall contain the caliber family of the specimen. This field shall consist of a single entry from Table 10.

Table 10. Caliber Families	
FAMILY CODE	DESCRIPTION
CL14	40 Caliber/10 mm Family
CL30	30 Caliber/Family
CL38	38 Caliber/9 mm Family
CL44	44 Caliber Family
CL32	32 Caliber Family
CL45	45 Caliber Family
CL22	22 Caliber Family
CL2L	22 SH/L Caliber Family
CL2A	25AU Caliber Family
CL9M	9MAK Caliber Family

3.7.13 FIELD 12.013: IMAGE SIZE IN PIXELS (ISP)

This field shall contain two information items separated by the US character describing the image area contained in the BDF. The first entry shall be the number of pixels in a horizontal line; the second entry shall be the number of lines of pixels contained in the image.

3.7.14 FIELD 12.014: IMAGE SIZE IN MILLIMETERS (ISM)

This field is necessary if the horizontal and vertical resolutions were not provided in the JFIF APP0. If present, this field shall contain two information items separated by the US character. The first entry shall be the horizontal dimension of the image in millimeters; the second entry is the vertical dimension of the image in millimeters.

3.7.15 FIELD 12.015: GRAYSCALE COMPRESSION ALGORITHM (GCA)

This mandatory ASCII field is used to specify the algorithm used to compress the image. An entry of "NONE" shall be used to indicate that the image data is in an uncompressed form; an entry of "JPEGB" indicates that lossy baseline JPEG was used to compress the image; and an entry of "JPEGL" identifies the compression algorithm as lossless JPEG.

3.7.16 FIELD 12.016: CAMERA LINEARITY CORRECTION (CLC)

The entry in this field shall be used to account for any non-linearity in the image capturing system. This non-linear dependence is often called the gamma correction. It will be in the range of 0.00 to 2.99. If the gamma correction is unknown, a value of 0.00 is required.

3.7.17 FIELD 12.017: COMMENT (COM)

The optional field can be used to convey comments regarding the transaction. It contains one or more free-form textual comments separated by the RS character.

3.7.18 FIELD 12.020 BREECH FACE MARKINGS TYPE (BMT)

This field shall identify the pattern of the markings on the breech face. An appropriate entry chosen from Table 11 shall be contained in this field.

Table 11. Breech Face Markings

BMT CODE	TYPE OF MARKING
S	Smooth (No Traces)
C	Concentric Circles or Spirals Around Center
P	Parallel (Any Direction)
X	Cross-Hatched
G	Granular
A	Arcs
O	Other
U	Unknown/Unable to Determine

3.7.19 FIELD 12.021: EXTERNAL BREECH FACE CIRCLE POSITION (XBP)

This field shall consist of three information items, separated by the US character. The first item shall be the horizontal pixel position of the center of the circle positioned around the external limit of the breech face area. The second item shall be the corresponding vertical position. The third item shall be the radius of the circle expressed as an integer number of pixels.

3.7.20 FIELD 12.022: INTERNAL BREECH FACE CIRCLE POSITION (IBP)

This field shall consist of three information items, separated by the US character. The first item shall be the horizontal pixel position of the center of the circle positioned around the internal limit of the breech face area. The second item shall be the corresponding vertical position. The third item shall be the radius of the circle expressed as an integer number of pixels.

3.7.21 FIELD 12.023: FIRING PIN IMPRESSION SHAPE (FPI)

This field shall identify the shape of the firing pin impression. An entry chosen from Table 12 shall be entered in this field. Multiple entries separated by the RS character may be used to correlate on more than one shape.

Table 12. Firing Pin Impressions

FPI CODE	FIRING PIN IMPRESSION SHAPE
C	Circular (Flat Base)
H	Hemispherical
R	Rectangular (Flat Base)
E	Elliptical (Similar to those Produced by Glock & S.W.D. Pistols)
O	Other/Irregular
U	Unknown/ Unable to Determine

3.7.22 FIELD 12.024: FIRING PIN IMPRESSION MARKS DESCRIPTOR (FPM)

This field shall contain a descriptor of the firing pin impression marks. An appropriate entry chosen from Table 13 shall be contained in this field.

Table 13. Firing Pin Impression Marks Descriptor

BMT CODE	TYPE OF MARKING
S	Smooth (No Traces)
C	Concentric Circles or Spirals Around Center
P	Parallel (Any Direction)
X	Cross-Hatched
G	Granular
A	Arcs
O	Other
U	Unknown/Unable to Determine

3.7.23 FIELD 12.025: FIRING PIN DRAG DESCRIPTOR (FDD)

This field shall contain a descriptor of the firing pin drag mark. An entry chosen from Table 14 shall be entered in this field.

Table 14. Firing Pin Drag Descriptor

DRAG CODE	DESCRIPTION
D	Drag Mark out of Firing Pin Impression
N	No Pronounced Firing Pin Drag
U	Unable to Determine

3.7.24 FIELD 12.026: FIRING PIN POSITION (FPP)

This field shall consists of three information items, separated by the US character. The first item shall be the horizontal pixel position of the center of the circle positioned around the external limit of the firing pin area. The second item shall be the corresponding vertical position. The third item shall be the radius of the circle expressed as an integer number of pixels.

3.7.25 FIELD 12.027: EXTRACTOR/EJECTOR LOCATIONS (EEL)

This field shall contain the positions of all extractor and ejector marks present in terms of hours on a clock face. Marks falling between clock positions shall be coded according to the nearest hour position. If in doubt, code according to the next higher value. If the chamber is cut out for the extractor, a "C" shall be immediately (without a space) appended to the clock position. The RS separator character shall be used between multiple entries.

3.7.26 FIELD 12.028: EJECTOR MARK POSITION (EMP)

This field shall consist of three information items, separated by the US character. The first item shall be the horizontal pixel position of the center of a circle around the external limit of the cartridge-case base. The second item shall be the corresponding vertical position. The third item shall be the radius of the circle expressed as an integer number of pixels.

3.7.27 FIELD 12.029: EJECTOR CONTOUR POSITION (ECP)

This field shall contain the coordinates of the contour of the geometric delimiter of the ejector mark. A series of imaginary intersecting lines forming a polygon will be constructed over the ejector mark to approximate its general shape. This polygon will usually consists of 4 to 10 sides. The horizontal and vertical pixel positions for each of the vertices of the polygon shall be recorded as a series of repeating subfields. The first information item of the each subfield shall contain the horizontal position of a vertex and the second item shall contain the vertical position of the vertex.

3.7.28 FIELD 12.030: RIMFIRE CONTOUR POSITION (RCP)

This field shall contain the coordinates of the contour of the geometric delimiter of a rimfire image. A series of imaginary intersecting lines forming a polygon will be constructed over the rimfire to approximate its general shape. This polygon will usually consist of 4 to 10 sides. The horizontal and vertical pixel positions for each of the vertices of the polygon shall be recorded as a series of repeating subfields. The first information item of the each subfield shall contain the horizontal position of a vertex, and the second item shall contain the vertical position of the vertex.

3.7.29 FIELD 12.999: IMAGE DATA (IMG)

This field is used to submit an image to a remote host system for correlation or to return an image that results from either a successful correlation or a laboratory's request for an image. It shall contain the image data from a cartridge case. It may be compressed or uncompressed as specified by the GCA entry. If the image data is compressed, it shall be encoded in accordance with the JPEG standard for the lossless or baseline modes of operation. JPEG files shall contain the JFIF APP0 marker segment as described in the JFIF APP0 Marker Segment Section 3.9 of this document.

3.8 END OF TYPE-12 LOGICAL RECORD

For the sake of consistency, immediately following the last byte of textual or image information in the Type-12 record, an FS character shall be used to separate logical records. By use of this method several imaged cartridge areas can be contained in a BDF.

3.9 JFIF APP0 MARKER SEGMENT

In the encoded JPEG file the JFIF APP0 marker code is present immediately after the SOI marker to identify the presence of the JFIF APP0 segment. It is identified by the zero terminated string "JFIF." Information that is missing from the JPEG stream that may be required to process the image is provided by this marker segment.

Table 15 summarizes the fields required for the JFIF APP0 marker segment. The contents and order of each item or field must appear in the interchange file as listed in Table 15. The following paragraphs provide additional information for each of the APP0 fields.

Table 15. JFIF Marker Segment Fields		
FIELD	LENGTH (BYTES)	HEXCODE
SOI	2	X'FFD8'
APPO	2	X'FFE0'
Length	2	X'0010'
Identifier	5	X'4A46494600'
Version	2	X'0102'
Units	1	X'0z'
Xdensity	2	X'xxxx'
Ydensity	2	X'yyyy'
Xthumbnail	1	X'00'
Ythumbnail	1	X'00'

3.9.1 SOI

The Start Of Image (SOI) marker is not part of the JFIF segment. It is present in Table 15 for the sole purpose of indicating the beginning of the JPEG file.

3.9.2 APP0

Every application marker segment begins with a two-byte hex code. The JFIF format uses the APP0 code as the application marker code. This marker code must immediately follow the SOI marker code.

3.9.3 LENGTH

The number contained in this field represents the total APP0 segment byte count, including the byte count value (2 bytes), but excluding the APP0 marker code. For the ballistic file application, this field shall always have a value of 16 (decimal).

3.9.4 IDENTIFIER

The characters contained in this field, "JFIF" terminated by a null character (00), uniquely identify this marker segment as one complying with the JFIF specification.

3.9.5 VERSION

This is the level of the JFIF specification implemented. The most significant byte indicates the major revision and the least significant byte the minor revision. Version 1.02 is the current released revision.

3.9.6 UNITS

This field specifies the units used for scanning resolution. The value of z may be "0," "1," or "2." A value of "1" indicates that the Xdensity and Ydensity fields are in terms of dots per inch; a value of "2" indicates dots per centimeter. A value of "0" indicates that there is no unit of measurement and that Xdensity/Ydensity quotient results in the pixel aspect ratio rather than image resolution. As non-square pixels are discouraged for portability reasons, the Xdensity and Ydensity values should normally equal "1" when the Units field is "0."

3.9.7 XDENSITY

This field is used to specify the horizontal resolution of the image if the Units field contains a "1" or a "2." Otherwise, it indicates the horizontal component of the pixel aspect ratio.

3.9.8 YDENSITY

This field is used to specify the vertical resolution of the image if the Units field contains a "1" or a "2." Otherwise, it indicates the vertical component of the pixel aspect ratio.

3.9.9 XTHUMBNAIL

This field gives the horizontal dimension of the thumbnail image[5] included in this JFIF APP0. This presence of this field is mandatory for compatibility with previous versions of the JFIF. Its value shall be set to X'"00."

3.9.10 YTHUMBNAIL

This field gives the vertical dimension of the thumbnail image included in this JFIF APP0. This presence of this field is mandatory for compatibility with previous versions of the JFIF. Its value shall be set to X'"00."

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[5]Unless there is an acknowledged need for the use of thumbnail images, no considerations will be given to them in this report. If a need is identified, then provisions can be considered for the inclusion of thumbnail images.

4. MINIMUM INTEROPERABILITY

This section is intended to establish the framework for determining a minimal level of interoperability between the DRUGFIRE and IBIS ballistic identification systems with respect to electronic exchange of data. Simply stated, basic interoperability can be shown to exist if specimen images captured by either system can be searched against the other system and result in successful correlations. For purposes of this report, minimal interoperability requires that both systems can acquire images in the style of the dissimilar system, electronically exchange the images, perform correlations using such images from the dissimilar system, and return a limited list or image(s) of candidate identifications. In this first report, the details of networking or the protocols used to exchange data will not be addressed.

4.1 TRANSACTION CAPABILITIES

Interoperability requires that transactions from one system can be submitted to the dissimilar system and that useful and accurate results can be returned in response to these requests. To provide interoperability, both systems must be capable of formulating and processing each of the transactions listed in Table 6. These transactions are intended to illustrate a minimum functionality for interoperability between dissimilar systems. All the information that is needed to process these transactions shall be contained in the transmitted BDF. Section 3 of this report details the format for the required records, fields, and information items that make up the BDF. The list of transactions are not necessarily all-inclusive and may need to be enhanced in a networking environment. The following paragraphs are descriptions of each of these basic transactions.

4.1.1 CORGCD: CORRELATE USING DESCRIPTORS

This Type Of Transaction (TOT) is used by a laboratory to submit a request to a remote host system for correlation based on the general characteristic descriptors such as the caliber and firing pin impression shape. As no correlation of image data will be performed, there is no need to include the specimen's image data in the transaction. The purpose of this TOT is to filter or limit the host system's database search area to a reasonable number of candidates for which image correlations must be performed.

The submitter shall formulate a BDF containing a Type-1 record identifying the transaction as a "CORGCD" and one Type-12 record. The Type-12 record shall contain the required general information regarding the specimen and the general characteristic descriptor data. After completion of this correlation, the host system will formulate a BDF to be returned to the submitter. The BDF will be a single Type-1 record consisting of a SNDRES transaction type, the submitter's TCN, the host's TRN, and the number of correlated matches found.

4.1.2 CORIMG: CORRELATE USING DESCRIPTORS & IMAGE DATA

This TOT is designed to submit an image of a specimen to a remote host for correlation. Either the specimen's general characteristic descriptor data or the results of a previously submitted CORGCD transaction should be used to limit the number of image correlations that must be performed.

The submitter shall formulate a BDF containing a Type-1 record identifying this as a "CORIMG" transaction, and a Type-12 record. The Type-12 record will contain the required general information regarding the specimen, the general characteristic descriptor data, and the image data (field 12.999). The TRN containing the results from a previous CORGCD correlation may be used to eliminate a second correlation based on the general characteristic descriptors. The image data submitted will have been acquired in accordance with the specifications stated in Section 2. Examples of uncompressed images and compressed images using both lossless and lossy data shall be used.

After completion of this correlation, the host system will formulate a BDF to be returned to the submitter. The BDF will be a single Type-1 record consisting of a SNDRES transaction type, the submitter's TCN, the host's TRN, and the number of matches found. An ordered list of matches associated with the correlation, together with the scores, will be retained by the host system. This information is accessible to the laboratory that submitted the correlation by reference to the TRN associated with the correlation.

4.1.3 SNDRES: SEND RESPONSE TO SUBMITTER

This TOT is used by the host system to send a response back to the submitter of a correlation request. The BDF constructed by the host will consist of a Type-1 record containing the submitter's TCN and the host's TRN and the number of candidate matches found.

4.1.4 REQLIS: REQUEST LIST OF IMAGE NUMBERS

This transaction is used to request the list of identifying numbers of matches resulting from a previous CORGCD or CORIMG transaction. In a Type-1 record, the requester shall enter their TCN and the host system's TRN that can be linked to a previous correlation transaction.

4.1.5 SNDLIS: TRANSMISSION OF LIST OF CORRELATED IMAGES

This transaction, used by a remote host, is the response to the REQLIS transaction. The BDF for this transaction will contain a Type-1 record and a Type-12 record. The identification number of the specimen previously submitted for descriptor or image correlation shall be contained in field 12.004. The identification number(s) of the probable correlations shall be contained in field 12.005. If no correlations were determined, this field shall contain "NONE."

4.1.6 REQIMG: REQUEST IMAGE(S)

This transaction is intended to be used by a laboratory to request one or more images from a host system. The BDF for this transaction will contain a Type-1 and a Type-12 logical record. Field four of the Type-12 record shall contain the host system's identifying number(s) of the specimen image(s) requested. The requester is not required to format any field that is above 12.005.

Alternatively, if the images requested are the results of a previous correlation, the requester may enter the host's TRN for that correlation together with the number of images requested. This eliminates the need for the Type-12 record.

4.1.7 SNDIMG: TRANSMISSION OF REQUESTED IMAGE(S)

This transaction is the response to a REQIMG request. The BDF will contain a single Type-1 record and a Type-12 record for each image that was requested. The properly formatted image data shall be contained in field 12.999. The identification number of the submitted image shall be contained in field 12.004. The host's identification number for the correlated image will be contained in field 12.005 of the Type-12 record. If no image exists for the requested number, field 12.005 shall contain "NONE."

4.2 NETWORKING

To provide interoperability, both systems must be able to transmit and accept BDFs, process the required transactions, and return the results electronically. Initially, a low-level form of electronic interchange, such as a dialup modem, shall be used for communication purposes. Images acquired from one system in accordance with Section 2 and formatted for data exchange in accordance with Section 3 shall be transmitted to the dissimilar host system. These images shall be capable of being searched and correlated against a dissimilar host system's database. The communication packages used on both systems must not be proprietary to either system. Different packages can be used on both systems, but they are required to interact with each other and they both must be commercially available off-the-shelf.

4.3 NETWORKING RECOMMENDATION

To satisfy the minimal interoperability requirements as outlined in this report, a dialup modem can be used for the physical exchange of data. However, this method of communication should not be considered as an acceptable standard operating procedure for production purposes.

Once it has been established that minimal interoperability, as regards searching and image correlation, exists between the dissimilar systems, the focus should be directed toward interoperability solutions in a "lights out" environment. Specifically, this requires that images can be captured and transactions exchanged and processed by dissimilar systems in an asynchronous manner without the need for human intervention. Although not part of the agreements reached during the January meeting held at NIST, all parties should develop their systems in such a way that does not prohibit "lights out" operation.

ANNEX A

AN EXAMPLE OF THE USE OF THE SPECIFICATION

This annex is an example of the transactions that might occur between a remote laboratory requesting a correlation of an evidence against a host system's database. The transactions are a series of requests and responses between the remote laboratory and the host system. The data illustrated is fictional. The transactions and data entries are present only to give an example of the appearance of data formatted according to this specification. JPEG lossless mode was used to compress the image data with a resulting compression ratio of 1.8:1, which includes the required JPEG tables and formatting.

TRANSACTION 1: Remote laboratory to host system.

The remote laboratory initiates this transaction, which contains a Type 1 and Type 12 record. The host system is requested to search its database for correlations using the General Characteristic Descriptors (GCD) of a breech face. The host system should then perform automatic correlations between the submitted image and the results of the GCD search. (These two operations could also have been submitted as two separate transactions.)

TYPE-1 RECORD

* LENGTH (LEN)	1.01:117 $^{G}_{S}$
* VERSION (VER)	1.02:0100 $^{G}_{S}$
* CONTENT (CNT)	1.03:1 $^{U}_{S}$ 1 $^{R}_{S}$ 12 $^{U}_{S}$ 01 $^{G}_{S}$
* TYPE OF TRANSACTION (TOT)	1.04:CORIMG $^{G}_{S}$
* DATE (DAT)	1.05:19960530 $^{G}_{S}$
PRIORITY (PRY)	1.06:4 $^{G}_{S}$
* DESTINATION AGENCY IDENTIFIER (DAI)	1.07:DCFBIOOGUN5Y $^{G}_{S}$
* ORIGINATING AGENCY IDENTIFIER (ORI)	1.08:RVATF11GUN6Z $^{G}_{S}$
* TRANSACTION CONTROL NUMBER (TCN)	1.09:234567AB $^{G}_{S}$

TYPE-12 RECORD

* LENGTH (LEN)	12.001:67003 $\overset{G}{s}$
* IMAGE DESIGNATION CHARACTER (IDC)	12.002:01 $\overset{G}{s}$
* TEST OR EVIDENCE (TST)	12.003:EVID $\overset{G}{s}$
* SUBMITTED SPECIMEN ID (SSI)	12.004:2346ZZ $\overset{G}{s}$
* BALLISTIC IMAGE TYPE (BIT)	12.006:BRF $\overset{G}{s}$
* DATE OF INCIDENT (DTI)	12.007:19960229 $\overset{G}{s}$
* OPERATOR IDENTIFICATION (OPI)	12.008:Technician1 $\overset{G}{s}$
* IMAGE CAPTURE SYSTEM (ICS)	12.009:MSI $\overset{U}{s}$ 101 $\overset{U}{s}$ 2.3 $\overset{U}{s}$ SUNWS2 $\overset{U}{s}$ SOLARIS2.4 $\overset{G}{s}$
* IMAGE TARGET SYSTEM (ITS)	12.010:IBIS $\overset{U}{s}$ 01 $\overset{G}{s}$
* CALIBER DESCRIPTION (CAL)	12.011:44RM $\overset{G}{s}$
* IMAGE SIZE IN PIXELS (ISP)	12.013:300 $\overset{U}{s}$ 400 $\overset{G}{s}$
* IMAGE SIZE IN MILLIMETERS (ISM)	12.014:12.5 $\overset{U}{s}$ 12.5 $\overset{G}{s}$
* GRAYSCALE COMPRESSION ALGORITHM (GCA)	12.015:JPEGL $\overset{G}{s}$
* CAMERA LINEARITY CORRECTION (CLC)	12.016:2.1 $\overset{G}{s}$
* BREECH FACE MARKING TYPE (BMT)	12.020:S $\overset{G}{s}$
* EXTERNAL BREECH FACE CIRCLE POSITION (XBP)	12.021:140 $\overset{U}{s}$ 180 $\overset{U}{s}$ 100 $\overset{G}{s}$
* INTERNAL BREECH FACE CIRCLE POSITION (IBP)	12.022:150 $\overset{U}{s}$ 170 $\overset{U}{s}$ 45 $\overset{G}{s}$
* FIRING PIN IMPRESSION SHAPE (FPI)	12.023:C $\overset{G}{s}$
* FIRING PIN IMP MARKS DESC (FPM)	12.024:S $\overset{G}{s}$
* FIRING PIN DRAG DESCRIPTOR (FDD)	12.025:N $\overset{G}{s}$
* FIRING PIN POSITION (FPP)	12.026: 150 $\overset{U}{s}$ 200 $\overset{U}{s}$ 100 $\overset{G}{s}$
* IMAGE DATA (IMG)	12.999:
APP0 Marker Segment	X'FFD2', X'FFE0', X'0010', X'4A46494600', X'0102', X'1388', X'1388', X'00', X'00',
Compressed Image Data	< 66667 BYTE JPEG FILE>
End Of Image Marker Code	X'FFD9' $\overset{F}{s}$

* MANDATORY FIELDS

TRANSACTION 2: Host system to remote laboratory.

After the host system has performed image correlations against its database using the submitted GCD as a filter, the count of candidate matches (19) is returned to the remote laboratory. The remote laboratory can then request a list of the candidate matches and then the actual candidate image files as separate transactions.

TYPE-1 RECORD

* LENGTH (LEN)	1.01:123 $^{G}_{S}$
* VERSION (VER)	1.02:0100 $^{G}_{S}$
* CONTENT (CNT)	1.03:1 $^{U}_{S}$ 0 $^{G}_{S}$
* TYPE OF TRANSACTION (TOT)	1.04:SNDRES $^{G}_{S}$
* DATE (DAT)	1.05:19960530 $^{G}_{S}$
* DESTINATION AGENCY IDENTIFIER (DAI)	1.07: RVATF11GUN6Z $^{G}_{S}$
* ORIGINATING AGENCY IDENTIFIER (ORI)	1.08: DCFBIOOGUN5Y $^{G}_{S}$
* TRANSACTION CONTROL NUMBER (TCN)	1.09:234567AB $^{G}_{S}$
* TRANSACTION RESPONSE NUMBER (TRN)	1.10:RV123 $^{G}_{S}$
* NUMBER OF MATCHES (NUM)	1.11:19 $^{G}_{S}$